Fermilab TRAC Program 2012

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TRAC Presentation

- Background information on LAPD
- Phase II of LAPD
- Background information on Bo
- Long Bo
- My contribution to Long Bo and LAPD

LAPD

Liquid Argon Purity Demonstrator (LAPD)

Phase I Goal:

The main goal is to show that the required electron lifetimes can be achieved without evacuating an empty tank by using gaseous argon purge, followed by gaseous argon filtration, followed by liquid fill and filtration. (Rebel, 2012).

Photo by Terry Tope

LAPD

Background:

In sensitive neutrino experiments, liquid argon tanks can provide 3D detailed images of the neutrinos interacting with the liquid argon. “The neutrinos interact with the nuclei in the argon and produce charged particles. These particles spawn electrons that then drift toward an array of wire detectors. The distance the electrons drift, along with arrival information gathered from the wires, provides scientists with a detailed 3D reconstruction of the event” (Hooker, 2011).

LAPD

The liquid argon needs to be as pure as possible (limit of 100 parts per trillion of oxygen contamination) to keep the electrons from interacting with other particles such as oxygen and water molecules.

Currently scientist must evacuated the liquid argon tank to remove the oxygen and water from the air in the chamber before filling the tank with argon. Large liquid argon tanks are needed for bigger detectors. However, large liquid argon tanks that can remain stable through the evacuation process is very expense.

LAPD

Therefore, LAPD experiments goal is to purify the argon without evacuating the air from the tank first.

LAPD

Process:

Step one

- Argon gas is added to the tank which pushes out the air.

Step two:

- The argon gas is recirculated through the entire tank to further reduce contamination levels.

Step Three:

- Once the purity levels are reached, liquid argon is added to the system

Step Four:

- The liquid argon is recirculated throughout the tank using pipes and filters for separating water, oxygen and other contaminants from the argon.

(Hooker, 2011)

LAPD

Phase One Results:

- After 11 volume exchanges of argon liquid , the electron lifetime was 3 ms. LBNE (Long-Baseline Neutrino Experiment) requires 1.4 ms
- However, the electron lifetime started decreasing after two weeks due to the filers being saturated. Then the filters were regenerated
- Electron lifetime increased to 5 ms

(Rebel, 2012)

LAPD

Phase Two Goals:

- Use Long Bo to test the purification of the liquid argon
- Continue to study the filter performance
- Study temperature changes in the liquid argon
- Study the effect of varying the flow rate of the liquid argon on the electron lifetimes
- Study the recover of the electron lifetimes after the system is intentional contaminated

Bo

Bo is a liquid-argon time projection chamber (TPC) that displayed its first cosmic ray particle tracks on August 5, 2011.

Photo: Hans Jostlein (left) and Kelly Hardin prepare the liquid-argon time projection chamber for lowering into Bo

Bo

- **Bo is a cylindrical time projection chamber that is 50 centimeters high and 20 centimeters in diameter.**
- **How does a Time Projection chamber work?**

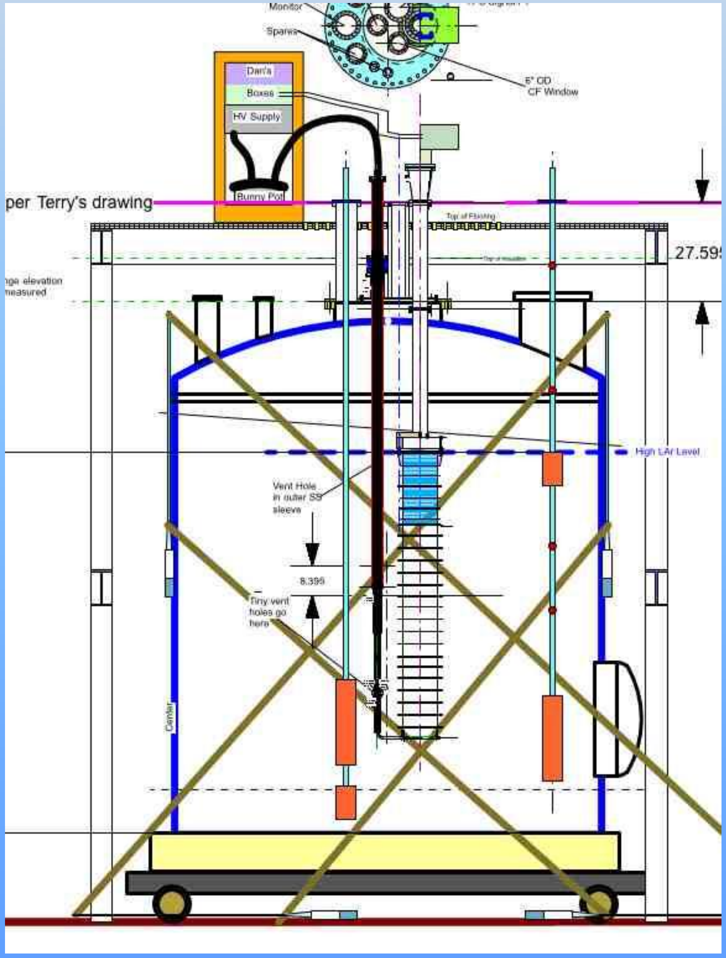
  Charged particles will ionize the argon atoms in the tank. When the argon atom is ionized an electron is removed from the argon atom. This will leave a trail of electrons which will then be moved in a uniform electric field to planes of wires. These wires allow the electrons particles to be track throughout the liquid argon.

Long Bo

Goal:

- Demonstrate a working TPC with long drift in LAPD
- Demonstrate a working HV system
- Demonstrate low noise

(Jostlein, 2011)



Long Bo

- Long Bo extends the previous Bo testing

- Will be placed in LAPD during the second phase

- Long Bo will provide the first long drift distance test at Fermilab, has spurred tests of HV feed through (100kV) that are benefitting MicroBooNE

Summer Internship

- **Created a phantom (model) of the TPC for Long Bo**

Purpose: The purpose of the model is it to test the installation of the TPC with the crane inside LAPD without using the real TPC to prevent damage to the TPC and its electronics

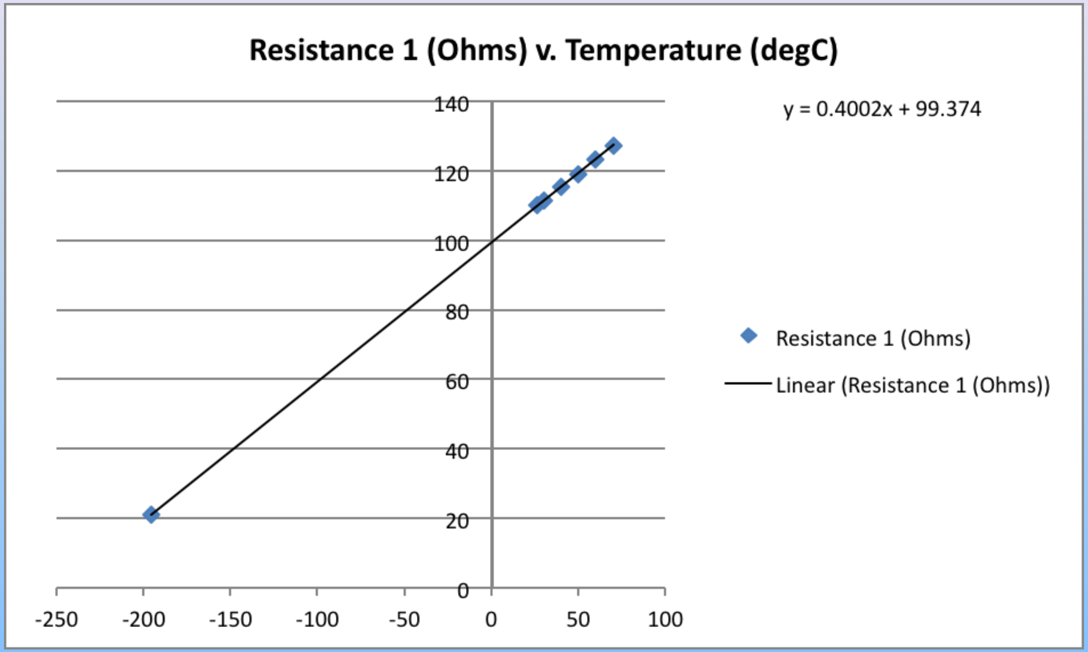
TPC Model

Summer Internship

- **Tested the three RTDs (resistive thermal devices) that will be placed inside the LAPD**

Purpose: The purpose for testing the three RTDs was rate the RTD changes temperature per ohm.

Results for RTDs

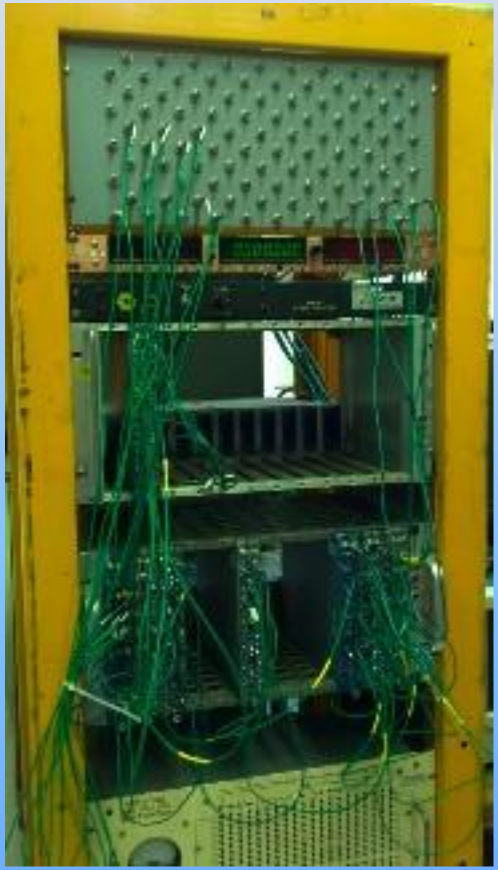


- Analysis:

The equations for all three RTDs were very similar. The RTDs changed at a relatively constant rate of 2.5 degrees C per Ohm.

Summer Internship

Set-up NIM module electronics for some of the counters for the Long Bo experiment.



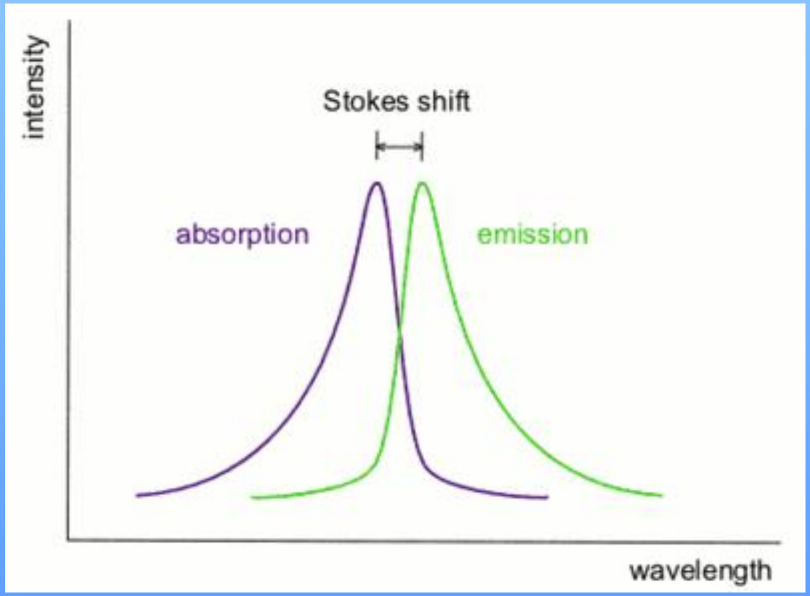
Summer Internship

- **Learned about the stoke shift and how it relates to the counters we were testing**

When the cosmic rays pass through the counters, the photons are absorbed by the scintillator in the counters. The photons are then released at a lower wavelength then absorbed. The difference in these energies is called the stoke shift.

Summer Internship

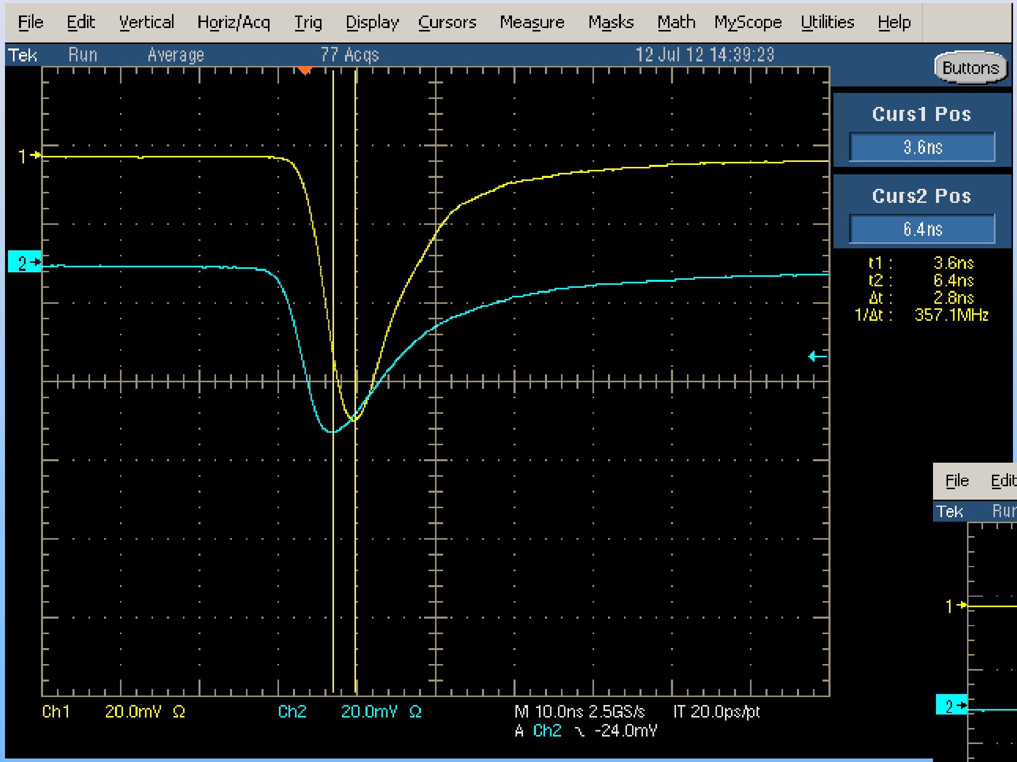
The stoke shift relates to my Chemistry classes when we discuss and conduct the flame test lab as well as our discussions on fireworks.



Summer Internship

Tested the time it takes for the signal to travel full length of counter

Results



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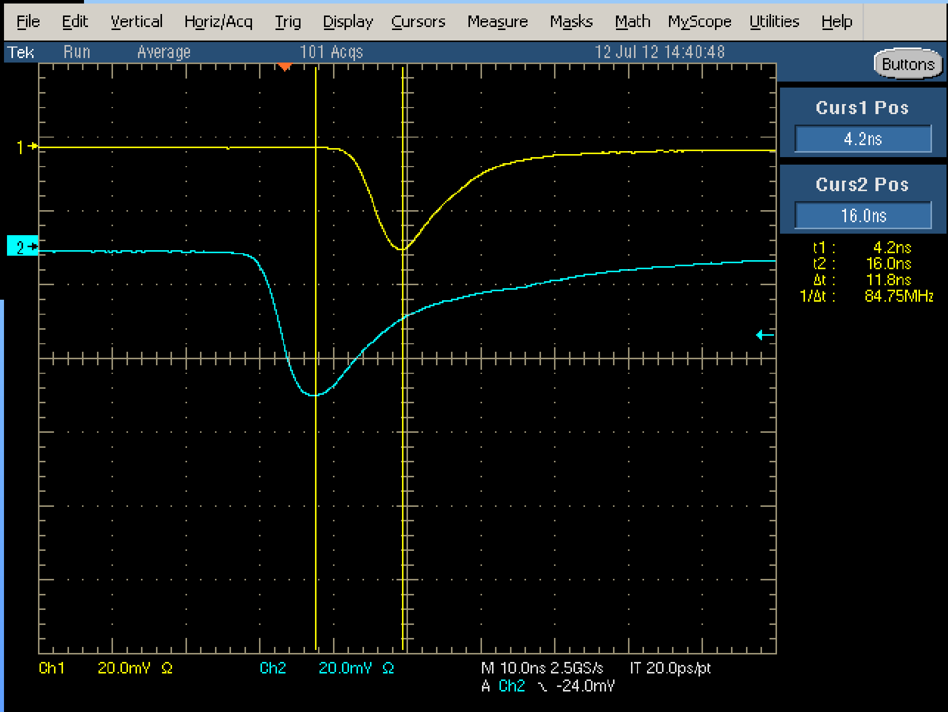
Tek Run Average 77 Acqs 12 Jul 12 14:39:23
Buttons
Curs1 Pos
3.6ns
Curs2 Pos
6.4ns
t1 : 3.6ns
t2 : 6.4ns
Δt : 2.8ns
1/Δt : 357.1MHz
Ch1 20.0mV Ω Ch2 20.0mV Ω M 10.0ns 2.5GS/s IT 20.0ps/pt
A Ch2 -24.0mV



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Tek Run Average 101 Acqs 12 Jul 12 14:40:48
Buttons
Curs1 Pos
4.2ns
Curs2 Pos
16.0ns
t1 : 4.2ns
t2 : 16.0ns
Δt : 11.8ns
1/Δt : 84.75MHz
Ch1 20.0mV Ω Ch2 20.0mV Ω M 10.0ns 2.5GS/s IT 20.0ps/pt
A Ch2 -24.0mV

RESULTS:

Counter Number	Time* (ns)	Minimum Signal (mV)	Minimum Voltage (V)
18	9.6	60	1600
19	11	12	1900
95	9.2	21	1700
132	11.2	20	1800
*Time is the time for light to go from one end of the counter to the other.			

Summer Internship

Did extensive research with the counters for Long Bo:

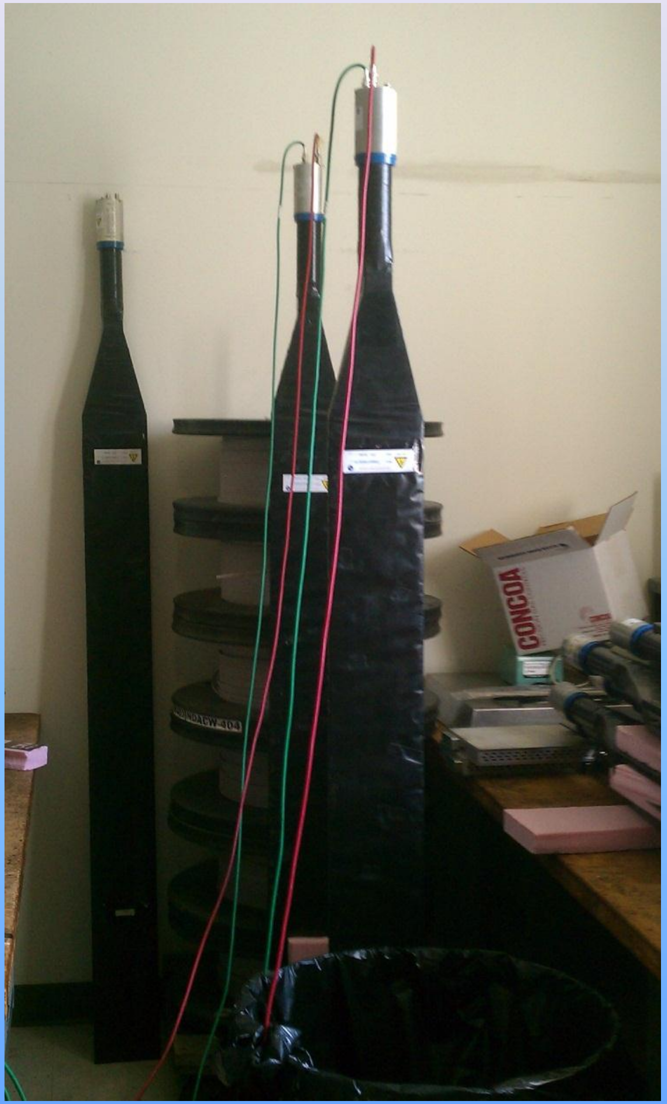
Purposes:

The purpose for testing the counters was to test the efficiency of the counters – two different ways. (Applied scientific method due to issues in testing.)

Counters

Set-up one:

Counters were vertically aligned with four counters in a row and the coincidence between counter 1,2, and 4 was recorded and the coincidence between all four counters was recorded. The difference showed the efficiency of the third counter.



Results from set-up one

Counter	Efficiency Percent	Uncertainty	Threshold (mV)	Voltage (V)
107	73.94	9.67	10	1720
138	63.51	8.57	10	1400

The data analysis created another question:
Why is the efficiency so low?

Counters

Set-up two:

Four counters were horizontally aligned. The data recorded was the coincidence between counter 1,2, and 4 and the coincidence between all four counters.

Results from Set-up two

Distance (m)	Efficiency	Counter	Uncertainty	Counter Position
0.50	97.97	47	1.43	Horizontal
0.50	97.44	138	1.43	Horizontal
0.50	98.66	21	1.40	Horizontal
0.50	98.85	138	1.40	Horizontal
1.00	96.20	21	0.22	Horizontal
1.00	96.72	138	0.22	Horizontal

Conclusion: The counter efficiency is close to 100% if the counters are tested in the horizontal position. Therefore, the following question can be asked: Why is the efficiency so low in the vertical position?

Results

Counters were tested with three counters aligned vertically and one off alignment several meters away. The counts were recorded for each individual counter and for the coincidence between the three aligned counters and the coincidence between two of the aligned counters and the offset counter.

Results:

Some of the muons are being missed because the cosmic ray showers are not passing through the middle counter.

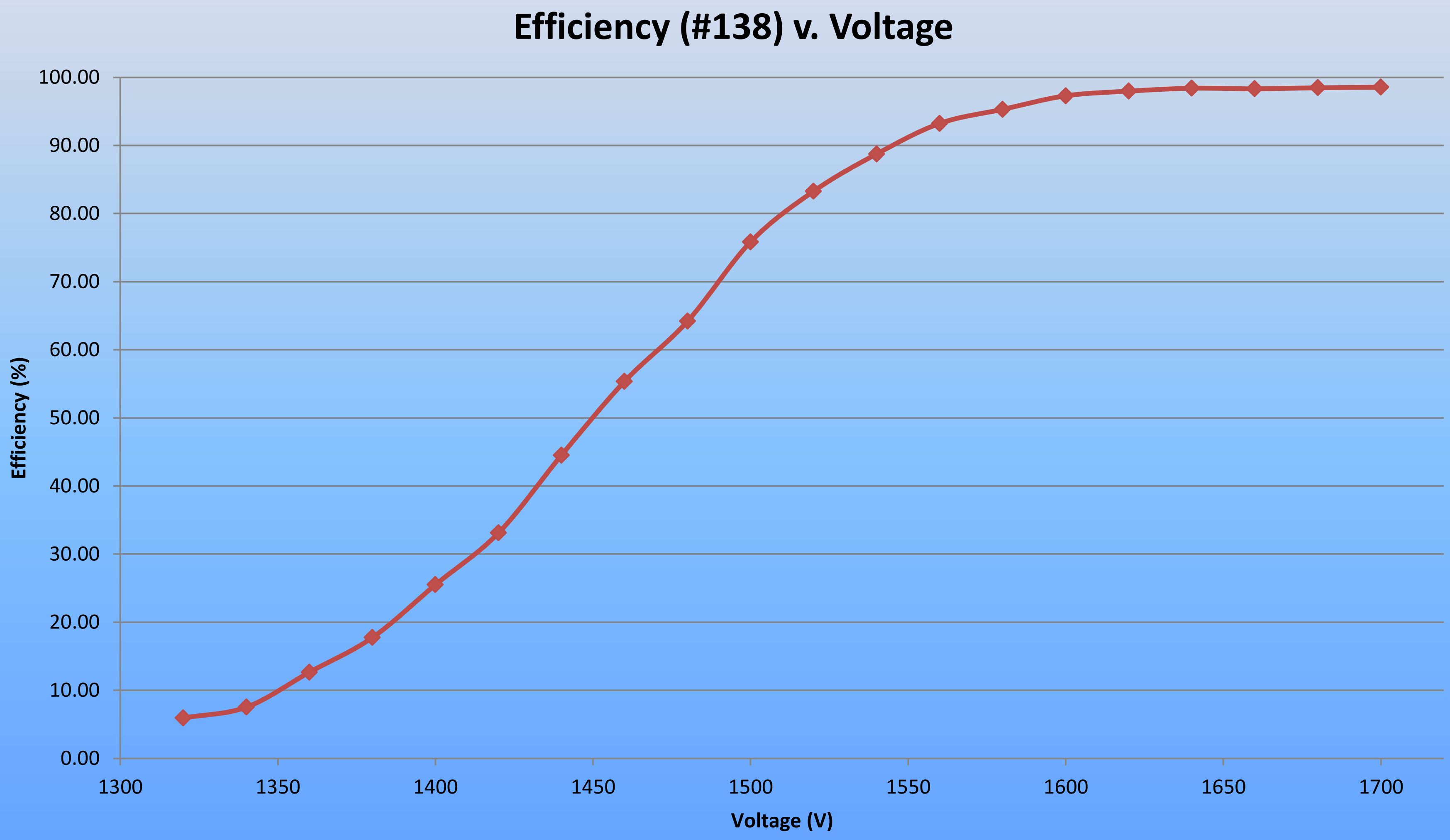
Summer Internship

Determined the most efficient operating voltages for each counter.

Results

Coincidence counts between counters 1 &2	Coincidence counts for all three counters	Voltage (V)	Efficiency
3317	197	1320	5.94
3313	249	1340	7.52
3368	426	1360	12.65
3332	591	1380	17.74
3354	855	1400	25.49
3372	1116	1420	33.10
3394	1511	1440	44.52
3355	1857	1460	55.35
3289	2111	1480	64.18
3393	2573	1500	75.83
3391	2824	1520	83.28
3369	2990	1540	88.75
3266	3045	1560	93.23
3363	3205	1580	95.30
3283	3194	1600	97.29
3315	3248	1620	97.98
3370	3316	1640	98.40
3381	3324	1660	98.31
3332	3281	1680	98.47
3407	3358	1700	98.56

Results



Efficiency (#138) v. Voltage
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Efficiency (%)
1300
1350
1400
1450
1500
1550
1600
1650
1700
Voltage (V)

Results

Counter #	Recommended Voltage (V)	Max Efficiency (%)
98	1600-1680	91.9
138	1640-1700	98.6
18-44	1500-1700	98.6
132	1580-1700	98.6
145	1660-1700	98.5
6	1580-1700	98.2
131	1600-1700	98.2
101	1500-1700	98.3
16	1560-1680	96.8
21	1560-1681	97.3
2	1520-1680	97.7
11	1520-1681	97.8
95	1700+	91.2
19-77	1680-1700	96.2
115	1720+	91.2
80	1480-1680	97.1
4	1480-1680	97.8
47	1400-1700	97.6

(With a different base, the efficiency went up to 94 @ 1680V)

Summer Internship

Designed the mounting system for the counters for the LAPD/Long Bo

Purpose: The purpose was to mount the counters to the outside system of LAPD for the detection of cosmic rays and the tracking of the electrons by the TPC

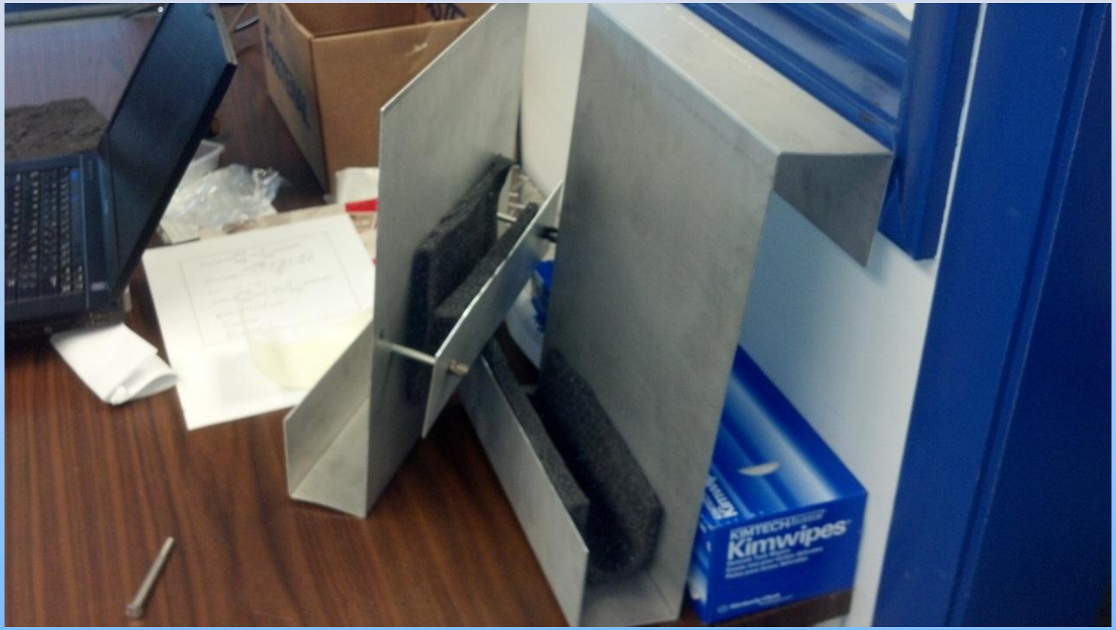
Mounting of counters to LAPD

First goal was to design the system to mount the counters on. Hans Jostlein suggested mounting the counters on ladders and then Lisa, Matt, and I had to figure out how to mount the ladders to the LAPD and how to mount the counters on to the ladders.

Mounting of counters to LAPD

Mounting of counters to LAPD

Mounting of counters to LAPD



Mounting of counters to LAPD

Thank You

- Stephen Pordes - Mentor
- Hans Jostlein
- Tingjun Yang
- Michelle Stancari
- Harry Cheung
- Bjoern Penning
- Lisa Carpenter
- Matt Hall

Resources

Hooker, B. (2011). A cheaper way to purify liquid argon for neutrino experiments. *Fermilab Today*, Retrieved from http://www.fnal.gov/pub/today/archive_2011/today11-12-16_LAPDReadMore.html.

Jostlein, H. Fermilab, Particle Physics Division. (2011).*Long bo for lapd* (687- v2). Retrieved from website: http://lartpc-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=687.

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